

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



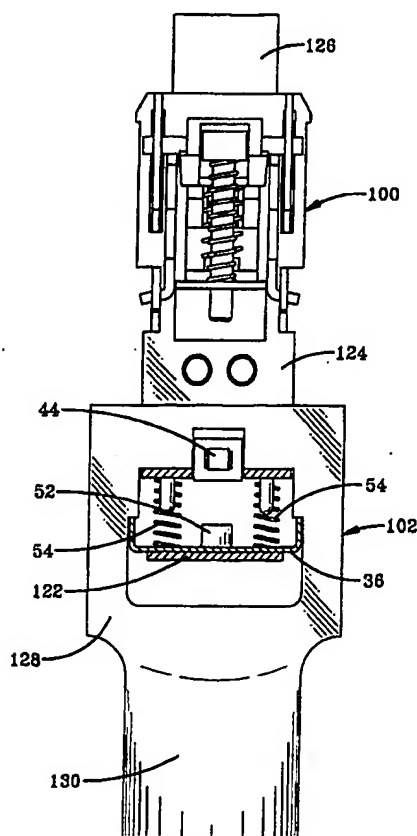
(43) International Publication Date  
25 October 2001 (25.10.2001)

PCT

(10) International Publication Number  
**WO 01/79039 A1**

- (51) International Patent Classification<sup>7</sup>: **B60R 21/01** (74) Agents: **DRAYER, Lonnie, R.**; Breed Automotive Technology, Inc., P.O. Box 33050, Lakeland, FL 33807-3050 et al. (US).
- (21) International Application Number: **PCT/US00/31446**
- (22) International Filing Date:  
15 November 2000 (15.11.2000) (81) Designated States (*national*): AT, AU, BR, CA, CN, CZ, DE, DK, ES, FI, GB, HU, ID, IN, JP, KR, MX, NO, NZ, PL, PT, RU, SE, TR, YU, ZA.
- (25) Filing Language: English
- (26) Publication Language: English (84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).
- (30) Priority Data:  
09/549,678 14 April 2000 (14.04.2000) US
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— with international search report
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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: **SEAT BELT TENSION SENSING DEVICE**



(57) Abstract: A seat belt tension sensing device has a seat belt tension sensor (102) and a seat belt buckle (100). The seat belt tension sensor has a means for detecting and transmitting information about magnetic field strength, a magnet (52), and springs (54) for positioning the magnet spaced from the sensor. The magnet is biased away from the sensor. The seat belt tension sensor maintained fixed relative to a structural member of a vehicle. The seat belt buckle is attached directly or indirectly to the seat belt tension sensor so that tension on the seat belt buckle moves the magnet and sensor closer together or further apart.

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## SEAT BELT TENSION SENSING DEVICE

The present invention relates to assemblies in which seat belt buckles cooperate with sensors to  
5 determine when and how vehicle occupant protection devices should be deployed.

An airbag system is made up of two basic functional components: an airbag module, including the means for deploying the airbag; and the sensors and  
10 circuitry which determine whether the airbag should be deployed.

Recently sensors have been developed to determine the weight imposed on the front seat. The value of the determined weight may then be used as input into  
15 the system logic that determines whether or not an airbag should be deployed. Furthermore, the value of the determined weight may be used as input into system logic which determines or whether the mode of deployment should be modified in airbag systems which  
20 are capable of varying the deployment sequence to accommodate varying circumstances. In some cases, however, these weight sensors can be confused by loads imposed by the compression of the seat resulting from installing a child's car seat and tensioning the seat  
25 belt to hold the child seat into place.

What is needed is a device comprising a seat belt buckle and a sensor that can provide data for determining whether a child's seat is positioned in the front passenger seat of an automobile.

30 Pretensioners are used to take up the slack in a seat belt in the event of a crash. However, if there is no significant slack in a seat belt because the

user has drawn the seat belt exceptionally tightly around him or has already taken up the slack by his forward movement as a result of a crash it may not be desirable to activate the pretensioner. What is  
5 needed is a device comprising a seat belt buckle and a sensor that can provide data for determining whether it is necessary to activate a pretensioner associated with the seat belt system.

These needs that are left unfilled by the prior  
10 art are now filled by the seat belt tension sensing device of claim 1. Seat belt tension is indicative of the presence of a child car seat because proper installation of a child car seat involves tightening the car seat belt as tight as possible to snugly hold  
15 the car seat in place. Thus a passenger will be uncomfortable with much less seat belt tension than a child seat will normally be installed with. When used in combination with a seat occupant weight sensor the assembly of a seat belt buckle and seat belt tension  
20 sensor allows direct determination of the actual weight of the seat occupant corrected for any loads imposed by a tensioned seat belt. In this way the weight of the seat occupant can be used with greater confidence to decide when and how an airbag should be  
25 deployed.

Brief Description of the Drawings

Fig. 1 is an schematic representation of a child car seat installed in a vehicle together with the seat belt tension sensor of this invention and a schematic of the airbag and airbag deployment system.

Fig. 2 is a front elevation view, partially broken away in cross-section, of the seat belt tension sensor of Fig. 1.

Fig. 3 is an exploded isometric view, partially broken away in section, of the seat belt tension sensor of Fig. 1.

Fig. 4 is a pictorial view of a first embodiment of an assembly of a seat belt buckle and a seat belt tension sensor in conjunction with a seat belt pretensioner.

Fig. 5 shows the seat belt tension sensor of Fig. 2 assembled with a seat belt buckle as employed in the embodiment of Fig. 4.

Fig. 6 is a pictorial view of a second embodiment of an assembly of a seat belt buckle and a seat belt tension sensor in conjunction with a seat belt pretensioner.

Fig. 7 is a pictorial view of a third embodiment of an assembly of a seat belt buckle and a seat belt tension sensor in conjunction with a seat belt pretensioner.

Fig. 8 shows the seat belt tension sensor of Fig. 2 assembled with a seat belt buckle as employed without a pretensioner.

Detailed Description of the Invention

Referring to Figs. 1-3 wherein like numbers refer to similar parts, a seat belt tension sensor 20 is fixed to a seat belt anchor bracket 22. As best shown in Fig. 1, the anchor bracket is mounted to a structural component 24 of a vehicle by a bolt 26. The anchor bracket 22, as shown in Fig. 2, has an opening 28 through which a loop 30 of seat belt webbing 32 passes. A hole 33 is formed in the lower portion 35 of the anchor bracket 22 through which the bolt 26 passes.

The seat belt loop 30 connects the seat belt 32 to the anchor bracket 22. When tension is applied to the seat belt webbing 32 the loop 30 is pulled toward the top side 34, or seat belt restraining side, of the opening 28 in the anchor bracket 22. As shown in Figs. 2 and 3, a sliding carriage 36 is positioned between the bottom 38 of the belt loop 30 and the top side 34 of the opening 28. The carriage 36 sides 46 have inwardly-turned edges 37 which guide the motion of the carriage 36 along the bracket 22. Reduced height end wall stops 39 are formed between the edges 37. The stops 39 serve to limit travel of the carriage 36. A circuit board 40 is mounted in a rectangular notch 42 in the top side 34 of the bracket 22. The circuit board 40 contains an integrated circuit chip 44 that incorporates a magnetic field sensor, preferably a GMR sensor.

As described below in detail, the magnetic field sensor measures the magnetic field present at the sensor and a microprocessor determines belt tension

based on the known spring constants and the strength of the measured magnetic field that is a function of displacement of the magnet. Thus the sensed magnetic field is directly proportional to carriage

5 displacement, carriage displacement is proportional to spring compression force based on a spring constant, and belt tension is equal to the determined compression force of the springs.

In Fig. 1 the sensor within the integrated  
10 circuit chip 44 is connected by wire leads 48 to a microprocessor 50. The microprocessor is connected to an airbag 51 and other sensors 53. The airbag is positioned with respect to a particular passenger seat 57 on which a passenger or a child car seat 55 is  
15 restrained by the seat belt 32. The decision to deploy an airbag is made by the microprocessor 50. The deployment decision is based on logic that considers the acceleration of a crash as detected by one or more crash sensors. Other criteria can include  
20 crash severity and data indicative of whether the front seat is occupied by a passenger who would benefit from the deployment of the airbag 51. Sensors that determine the weight of the occupant, the size of the occupant and the location of the seat have been  
25 developed. The seat belt tension sensor 20 supplies an important piece of information which can be considered by the microprocessor logic alone or with other data to reach a conclusion about the desirability of employing an airbag in a particular  
30 situation.

As shown in Fig. 3, the magnetic field sensor in the chip 44 responds to a magnet 52 which is affixed

to the bottom of the U-shaped sliding carriage 36.  
When tension is applied to the seat belt 32 it draws  
the carriage 36 against springs 54 toward the  
top side 34 of the opening 28 where the magnetic field  
5 sensor on the chip 44 is mounted. The magnetic field  
sensor responds to the intensity of the magnetic field  
that reaches the sensor on the chip. The sensor has a  
response that varies as belt tension draws the  
carriage 36 and the magnet 52 toward the magnetic  
10 field sensor on the chip. The magnetic field present  
at the magnetic field sensor is thus correlated with  
belt tension by the microprocessor 50.

The magnetic field sensor is preferably a GMR  
sensor that utilize an effect discovered in 1988, in  
15 which certain thin film devices are able to detect  
static magnetic fields. GMR sensors utilize resistors  
built up of thin magnetic film a few nanometers thick  
separated by equally thin nonmagnetic layers. A  
decrease in resistance of between about 10 and 20  
20 percent in the built-up resistors is observed when a  
magnetic field is applied. The physical explanation  
for the decrease in resistance is the spin dependence  
of electron scattering and the spin polarization of  
conduction electrons in ferromagnetic metals.

25 The extremely thin adjacent magnetic layers  
couple antiferromagnetically to each other so that the  
magnetic moments of each magnetic layer are aligned  
antiparallel to adjacent magnetic layers. Electrons,  
spin polarized in one magnetic layer, are likely to be  
30 scattered as they move between adjacent layers.  
Frequent scattering results in high resistance. An  
external magnetic field overcomes the

antiferromagnetic coupling and produces parallel alignment of moments in adjacent ferromagnetic layers. This decreases scattering and thus device resistance.

In an exemplary sensor a group of four resistors  
5 based on the GMR technology are arranged in a Wheatstone bridge and two legs of the bridge are shielded from the applied magnetic fields. The other two legs are positioned between the magnetic shields. The magnetic shields act as flux concentrators to  
10 produce a device of tailored sensitivity to a magnetic flux of a selected intensity. A regulated voltage or current is supplied to the resistor network and the variation in current or voltage is measured and correlated with magnetic field strength.

15 As an alternative the resistance of one or more GMR resistors may be measured directly by an ohmmeter incorporated in the microprocessor. The sensor can be designed to have an axis of sensitivity that is produced by the orientation of the magnetic flux  
20 shields within the chip 44. The axis of sensitivity in the sensor is aligned with the direction of motion of the carriage 36.

GMR sensors are available from Nonvolatile Electronics Inc. of 11409 Valley View Rd.,  
25 Eden Prairie, Minnesota U.S.A. ([www.nve.com](http://www.nve.com)). GMR sensors are small, highly sensitive devices that have exceptional temperature stability, deliver high signal levels and require very little power and cost less than many competitive devices. All these factors are  
30 important in devices used in automobile safety applications.



The carriage 36 not only supports tension loads when the seat belt 32 is tightened but also supports any crash-induced loads. Because crash loads are very large, the spring guides 60 are constructed of metal, preferably high strength steel. The spring guides may be riveted or force fit onto the anchor bracket 22. The spring guides 60 have guideposts 64 about which the coil springs 54 are positioned. Typical tension forces sensed are in the range of about 89 to 178 newtons. Tensions in this range are sufficient to differentiate between a child's car seat or other object and a person and if a seat belt retraining a person has sufficient slack to require the activation of a pretensioner. The carriage 36 is constructed of high strength steel both to absorb the loads in a crash and so that the sides 46 of the carriage 36 shield the magnetic field sensor from stray magnetic fields.

It should be understood that the springs can be of various designs including Belleville Springs, gas springs, and springs using other shapes and configurations.

It should be understood that although a sensor based on GMR technology is described, other types of magnetic field sensors such as Hall sensors and other solid state sensors as exist or may be developed could be used. In addition a simple reed switch, which is a type of magnetic field sensor, could provide binary or stepped information concerning displacement of a magnet.

It should also be understood that although a GMR sensor can be used with a reference voltage or

current, the change in resistance of one or more GMR resistors can be determined directly with a circuit which functions as an ohmmeter.

If the GMR sensor is used with voltage or current  
5 where the GMR sensor is an active part of a Wheatstone bridge, four wires are normally required. If the GMR sensor is used simply as a simple resistor, two wires are sufficient.

It should also be understood that other types of  
10 magnetic field sensors could be employed to detect the motion of the carriage 36 toward the sensor.

While the seat belt tension sensors disclosed thus far have been described as cooperating with the belt portion of a seat belt that is looped through the  
15 sensor, it is also desirable to provide seat belt tension sensing device wherein a seat belt buckle is attached directly or indirectly to the seat belt tension sensor so that tension on the seat belt buckle moves the means for detecting and transmitting  
20 information about magnetic field strength 44 and the magnet 52 closer together or further apart.

With reference to Fig. 8 there is shown a seat belt buckle 100 have a component 124 that is formed into a loop 122 which extends through the opening in  
25 the bracket 22 of the seat belt tension sensor 102 in substantially the same manner as the set belt did in the embodiment shown in Fig. 2. The bracket may be attached directly or indirectly to a structural member of a vehicle for example using a bolt (not shown)  
30 passing through a hole 33 in the bracket.

When a seat belt (not shown) is connected to the buckle 100 using a buckle tongue 126 tension on the

seat belt buckle cause the loop 122 to be pulled toward the top side, or seat belt buckle restraining side of the opening in the anchor bracket 22 in the manner already described above with regards to Figs. 2 and 3. The structure of the seat belt tension sensor, such as the sensor 44, magnet 52, springs 54 and carriage 36 are substantially is substantially the same as that already described above with regards to Figs. 2 and 3. The sensor is in circuit communication with a microprocessor as already described above. Such a seat belt tension sensing device has utility when a vehicle manufacturer wishes to locate a seat belt tension sensor on the "buckle side" of a seat belt system.

While the seat belt buckle is shown attached to the seat belt sensor by a loop, it is understood that in seat belt tension sensing devices of the present invention the seat belt buckle may be attached directly or indirectly to the seat belt tension sensor using any suitable attachment means so that tension on the seat belt buckle moves the magnet and sensor closer together or further apart including welding, brazing, rivets, threaded fasteners, clamping, twisting, interference fits, interlocking parts and so forth.

In some instances a vehicle manufacturer may desire to have a seat belt tension sensor located on the "buckle side" of a seat belt system that is equipped with a buckle side seat belt pretensioner. A solution can be described with reference to Figs. 4 to 7. Seat belt pretensioners located on the "buckle side" of a seat belt system are well known in the art.

A typical buckle pretensioner 104 has a cylinder 106 containing a piston that is driven by a pyrotechnic device 108 in a direction away from the seat belt buckle 100. The piston is connected to the seat belt buckle using a metallic cable 114. The pretensioner is attached directly or indirectly to a structural member of a vehicle using a fastener (not shown) passing through a hole 112 in a mounting bracket/cable guide 110. The cable is very strong and stiff, and does not move in a lengthwise direction unless the pyrotechnic device activates the pretensioner.

Figs. 4 and 5 show a seat belt buckle 100 (shown in Fig. 4 in a typical housing) attached to a seat belt tension sensor 102 in the manner already described above with regards to Fig. 8. In a seat belt tension sensing device having a seat belt pretensioner as a component of the device the seat belt tension sensor may be located in a number of places with respect to the pretensioner. In the embodiment shown in Figs. 4 and 5 the seat belt tension sensor 102 is attached to the cable 114 that is a component of the pretensioner. An extension 130 of the bracket 128 is formed into a cylinder like shape to facilitate attachment to the cable. In this example the seat belt tension sensor is attached to the cable using a washer 116 and a damper 118 which are encased in a crimping sleeve 120 along with the cylindrical like extension 130 of the bracket 128 of the seat belt tension sensor. It is understood that any suitable means may be used for attaching the seat belt tension sensor to the cable may be employed, such as welding, a loop through an opening in the sensor,

and so forth may be used in the practice of this invention. In the embodiment shown in Figs. 4 and 5 the seat belt buckle 100 is attached to the seat belt tension sensor using a loop 122 in the manner already described above with regards to Fig. 8.

The cable 114 of the pretensioner is typically a very strong stiff cable such that the bracket 128 of the seat belt tension sensor 102 is indirectly anchored to, and fixed relative to, a structural member of a vehicle. Tension in a seat belt (not shown) attached to the buckle 100 via a buckle tongue 126 is sensed by the sensor 144 as the magnet 52 is moved towards or away from the sensor in the manner already described above.

In the embodiment shown in Fig. 6 the seat belt buckle 100 is indirectly attached to the seat belt tension sensor 102 using a length of cable and the seat belt tension sensor is attached to a cable 114 that is a component of the seat belt pretensioner 104. In this example the loop 122 which acts upon the carriage 36 of the pretensioner is not attached directly to the buckle, but it still will move due to tension placed on the buckle, thus causing the magnet to move towards the sensor.

In the embodiment shown in Fig. 7 the pretensioner 104 is attached to the vehicle such that it may pivot through some preselected arc about a pin or threaded fastener that extends through the hole 112 in the mounting bracket/cable guide 110. The seat belt tension sensor 102 is fixed relative to a structural member of the vehicle using a fastener extending through a hole 33 in the bracket. Tension

on the seat belt buckle 100 pulls on the cable 114 causing the pretensioner to pivot and tension is transferred to the sensor via a loop 122 that connects the seat belt tension sensor to the pretensioner.

- 5 That is to say in the embodiment the buckle is connected indirectly to the seat belt tension sensor via the pretensioner.

Pretensioners are used to take up the slack in a seat belt in the event of a crash. However, if there  
10 is no significant slack in a seat belt because the user has drawn the seat belt exceptionally tightly around him or has already taken up the slack by his forward movement as a result of a crash it may not be desirable to activate the pretensioner. The seat belt  
15 tension sensing device of the present invention can provide data for determining whether it is necessary to activate a pretensioner associated with the seat belt system. A microprocessor can be connected by wire to the means for detecting and transmitting  
20 information about magnetic field strength (the sensor), and the microprocessor and determine if the pretensioner should be activated based upon the sensed seat belt tension. In addition to determining the presence of a child seat as a variable in determining  
25 how to activate vehicle occupant safety devices the microprocessor can use seat belt tension as a variable in determining if a pretensioner should be activated.

Claims:

1. A seat belt tension sensing device  
comprising:

5 (a) a seat belt tension sensor (20)  
comprising

(i) a bracket (22) adapted to be  
anchored directly or indirectly to a  
structural member of a vehicle, the bracket  
10 having portions defining an opening (28)  
through which a component of a seat belt  
buckle (100) is looped, wherein the bracket  
has a seat belt buckle restraining side;

(ii) a carriage (36) positioned within  
15 the bracket opening and movable toward the  
seat belt buckle restraining side;

(iii) a magnetic field sensor mounted  
on the seat belt buckle restraining side of  
the bracket;

20 (iv) a magnet (52) mounted on the  
carriage for motion toward the sensor  
mounted on the seat belt buckle restraining  
side; and

(v) at least one spring (54)  
25 positioned between the carriage and the  
restraining side, biasing the carriage away  
from the restraining side, wherein the  
carriage moves toward the restraining side  
when tension is applied to the seat belt  
30 buckle; and

(b) a seat belt buckle (100) having a loop member that extends through said opening in said bracket of said seat belt tension sensor.

- 5           2.    The seat belt tension sensing device of Claim 1 wherein the magnetic field sensor is of the type producing a continuously changing state as an applied magnetic field varies.
- 10           3.    The seat belt tension sensing device of Claim 1 wherein the sensor (20) is of the GMR type.
4.    The seat belt tension sensing device of Claim 1 wherein the sensor (20) is of the Hall effect  
15   type.
5.    The seat belt tension sensing device of Claim 1 wherein the sensor (20) is of the reed switch  
20   type.
6.    The seat belt tension sensing device of Claim 1 wherein the magnet (52) is positioned opposite the sensor (20) and further comprising a pair of  
25   spring guides (60) positioned on either side of the magnet, and springs (54) mounted on the guides, the guides extending from the bracket (22) toward the carriage (36), the guides positioned to limit the movement of the carriage toward the restraining side.
- 30           7.    The seat belt tension sensing device of Claim 1 wherein the carriage (36) is U-shaped having a U bottom on which the magnet (52) is mounted and



upstanding sides which shield the magnet and the sensor (20) from magnetic fields other than the field produced by the magnet.

- 5           8. The seat belt tension sensing device of any one of claims 1 through 7 wherein the seat belt tension sensor (20) is attached to a seat belt pretensioner (104) which is adapted to be attached directly or indirectly to a structural member of a  
10 vehicle.

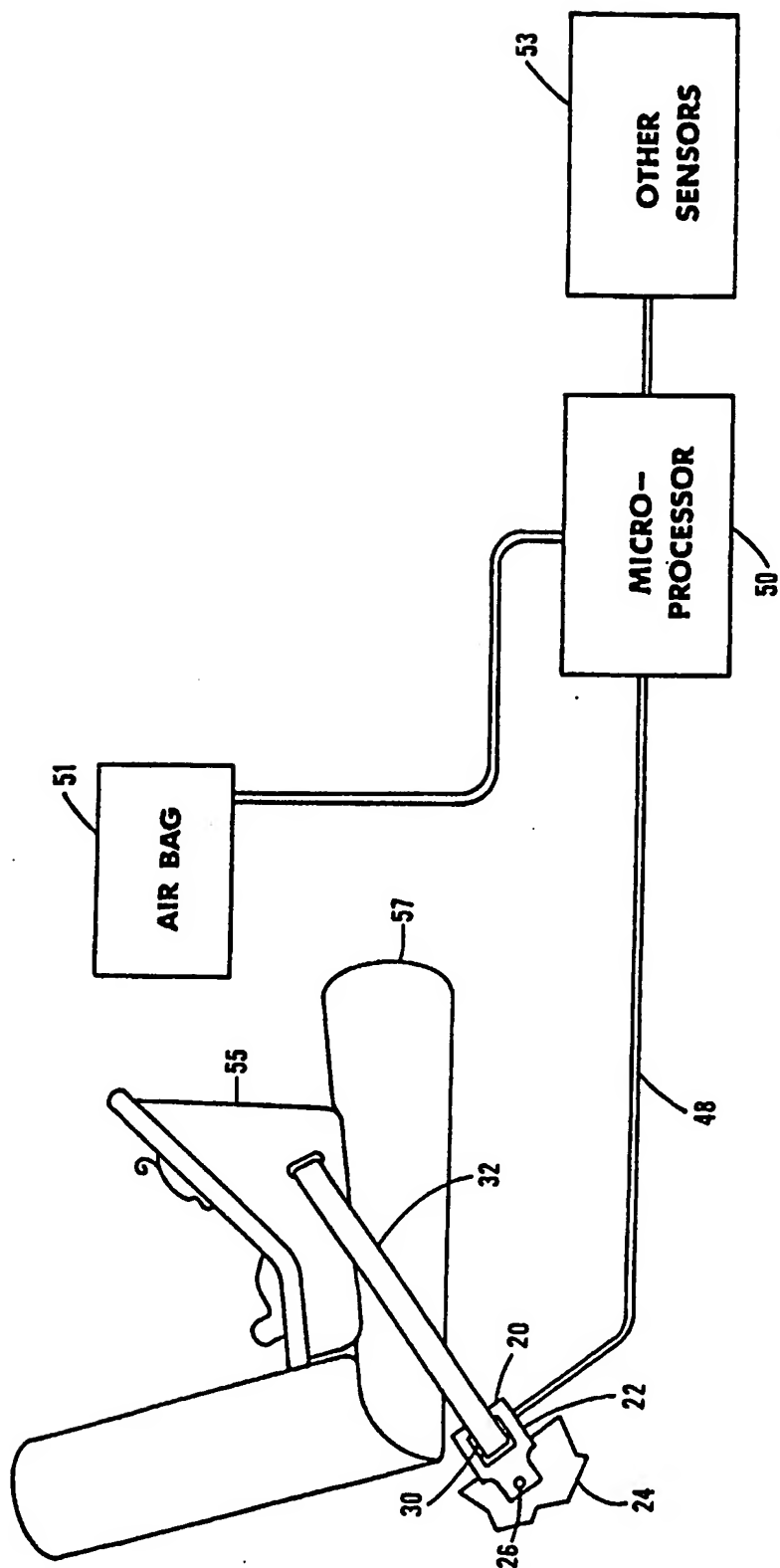


FIG. 1

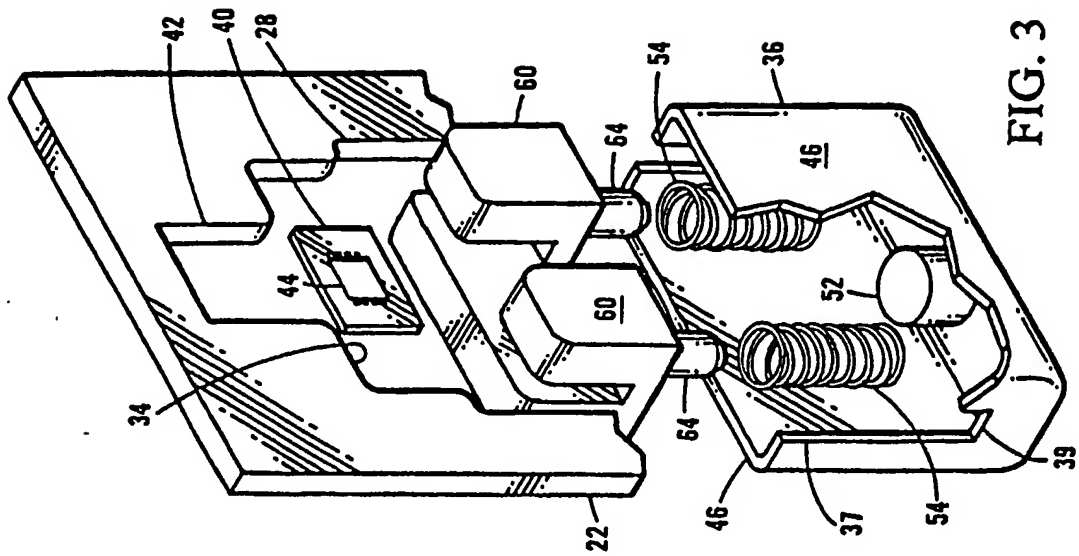


FIG. 3

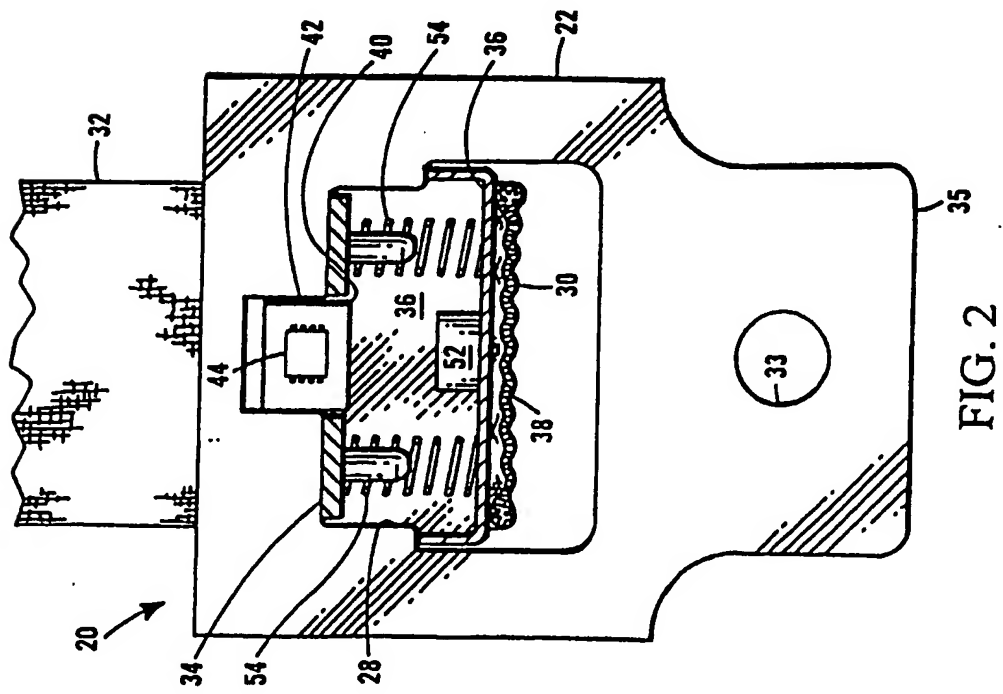


FIG. 2

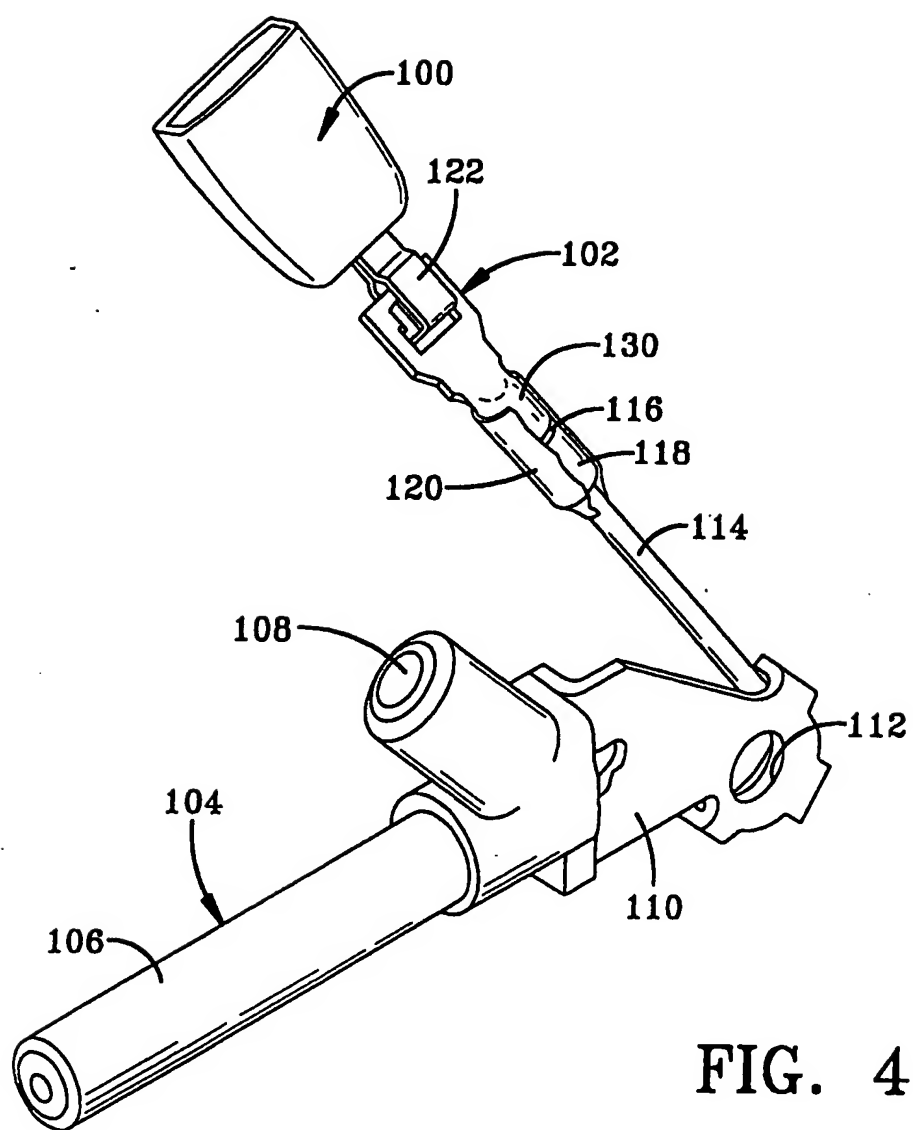


FIG. 4

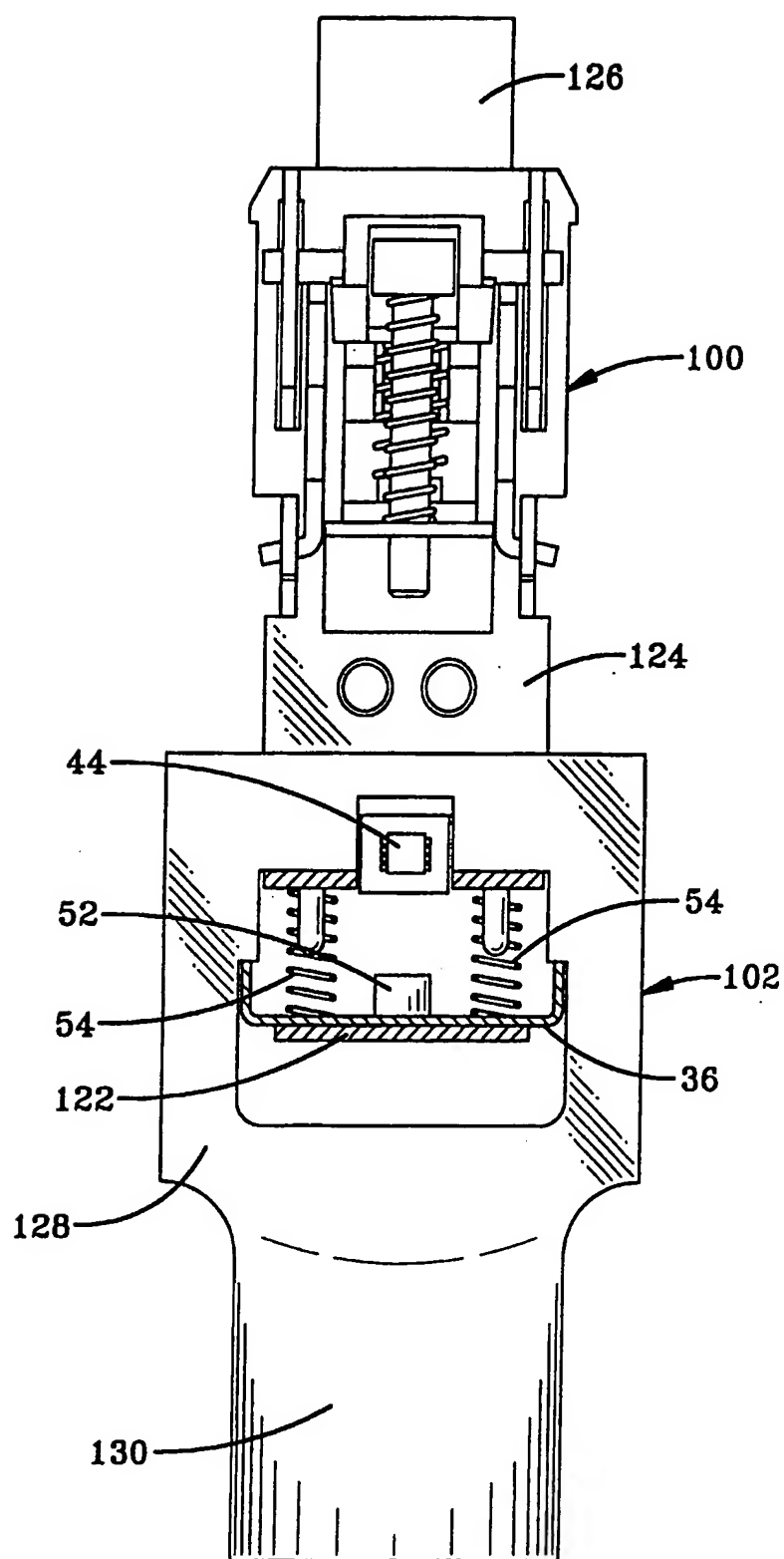


FIG. 5

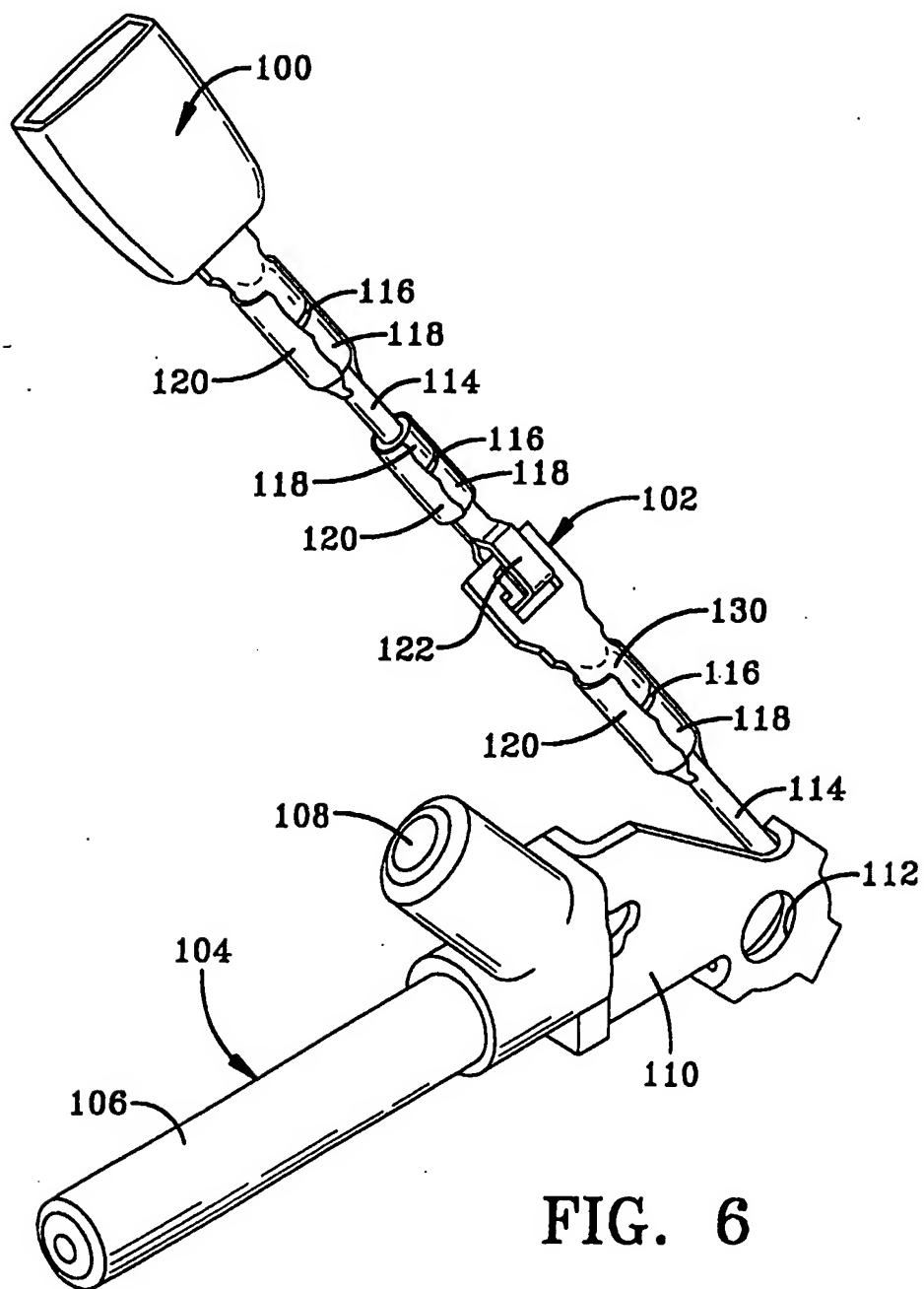


FIG. 6

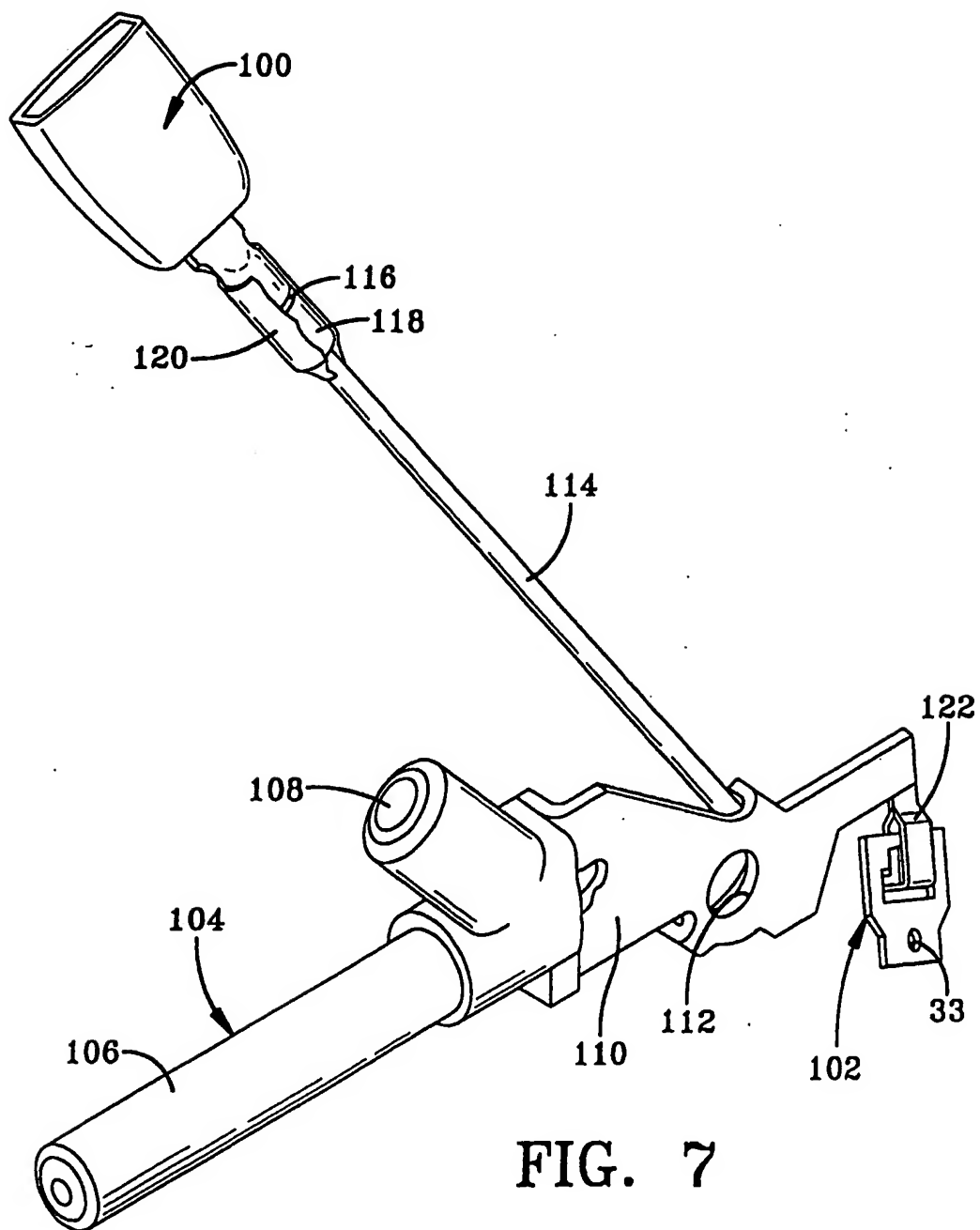


FIG. 7

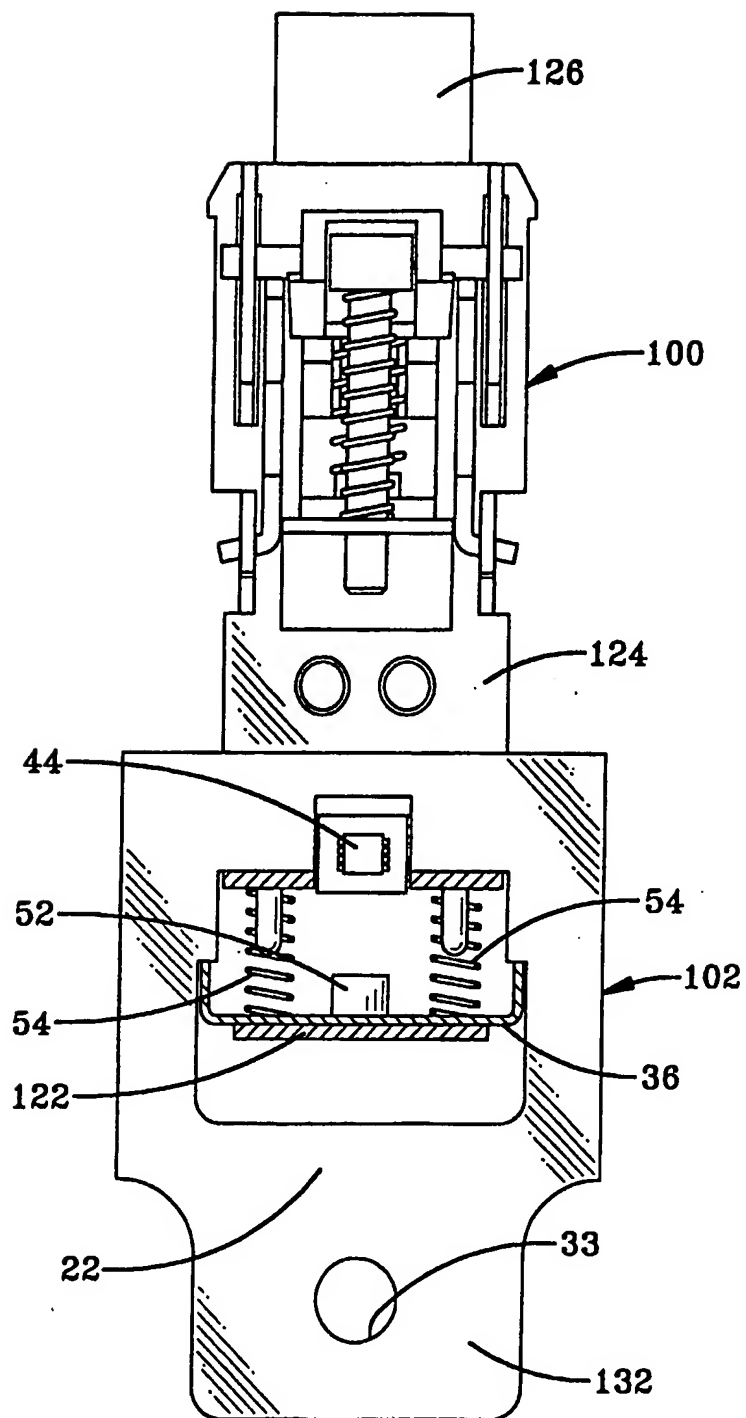


FIG. 8



## INTERNATIONAL SEARCH REPORT

Int. nat. Application No.

PCT/US 00/31446

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 B60R21/01

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A44B B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,Y	US 6 081 759 A (HUSBY HARALD SNORRE ET AL) 27 June 2000 (2000-06-27) the whole document	1-7
Y	US 5 960 523 A (HUSBY HARALD SNORRE ET AL) 5 October 1999 (1999-10-05) abstract column 2, line 37 - line 49 column 4, line 19 - line 62 figures 4-15	1-7
A	WO 99 27337 A (AUTOMOTIVE SYSTEMS LAB) 3 June 1999 (1999-06-03) page 3, line 20 - line 26 page 4, line 9 - line 11 page 7, line 10 - page 9, line 6; figures	1,6
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

1 March 2001

Date of mailing of the international search report

08/03/2001

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In      nal Application No

PCT/US 00/31446

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 99 12012 A (BREED AUTOMOTIVE TECH) 11 March 1999 (1999-03-11) abstract page 4, line 3 -page 6, line 16 page 8, line 12 - line 15 figures 2-4. _____	1,2

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Application No

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